Supply Chain Analytics

Prof. Dr. Rajat Agrawal
Department of Management Studies
Indian Institute of Technology-Roorkee

Lecture-15
Forecasting using Multiple Characteristics in Demand Data and Inventory Management in Supply Chain

Welcome back, so far we are discussing about the various forecasting models in the supply chain, and today also we will continue with the same discussion of forecasting methods in the supply chain. In our last session we discussed about the use of tracking signal in the decision making of the forecasting methods. Then we also discussed a case where we had the data, which is given to us for year 2016 and 2017.

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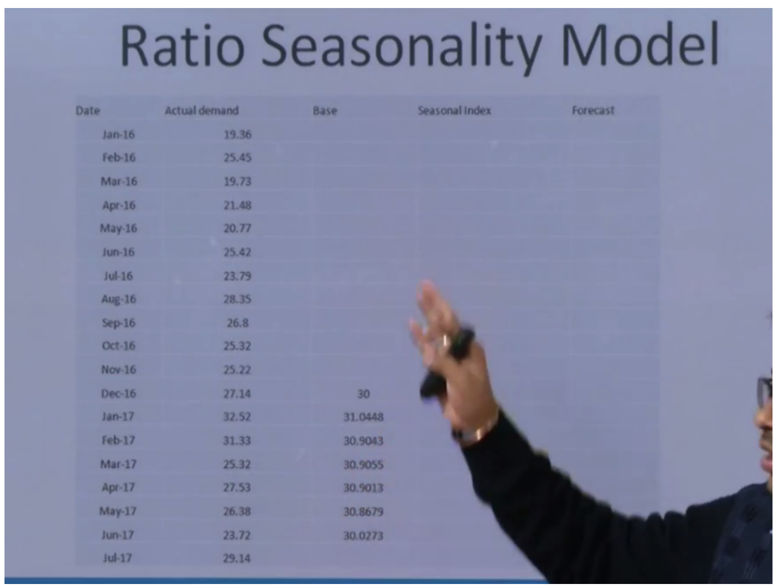

And we assumed initially that this data is representing ratio seasonality in it is case. And as we discussed that we need to have proper use of MAD as well as tracking signal for determining suitabilty of a forecasting model. And, it is almost impossible for anybody, that with this type of data, you can determine the characteristic of your data.

Sometime you have demand data like 50, 60, 50, 60 and then all of a sudden it increases to 90, 100 and then it remains 90, 100 and it comes to 50, 60 that way. So in that case you can say that there is a clear visibility of some kind of seasonality, but when you have this type of data which is 19, 25 again 19, 21, 20 like that. So it is no way that just by seeing the data you can analyse that this has the ratio seasonality or linear seasonality or trend or no trend or no seasonality kind of thing.

So, we discussed in the last session in detail that how to use tracking signal and how to use mean absolute deviation to determine the suitability of a particular type of forecasting model for the given set of data. Now we discuss the ratio seasonality in the last session. We will go further in this session beyond one type of component. In last to last lesson, we discussed only with our simple data. Then in the last session we discuss seasonality with simple data.

Now we will consider for the same set of data, that this data has trend as well as seasonality, so now we are assuming that this data does not have simply ratio seasonality. This data has trend as well as seasonality.So, now we are going with this type of model.

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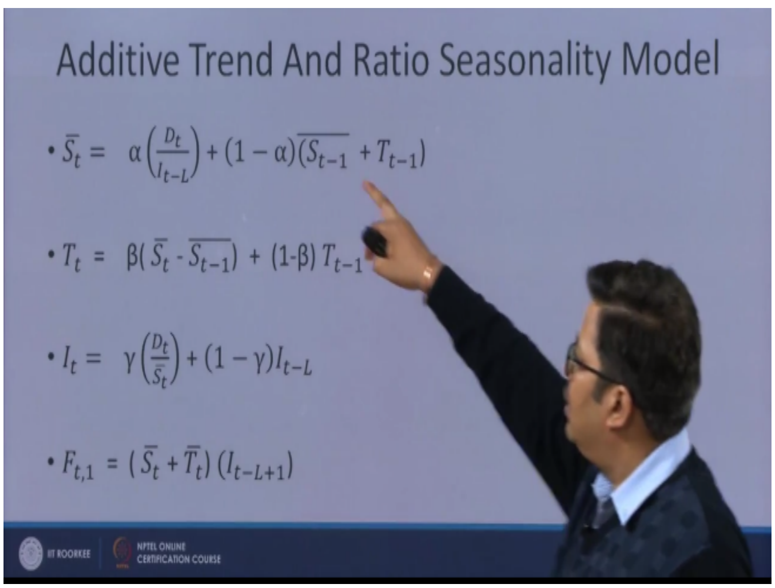

Where, this model has trend and seasonality, in case of trend we are assuming that this is the linear trend, this is the additive trend. You may be aware that in one of the session we discuss that there can be 2 types of trend. One is linear trend, which we are assuming here and linear trend is determined with the help of St - St - 1. This is the formula to determine the linear trend. And this formula of linear trend or additive trend is St - St - 1.

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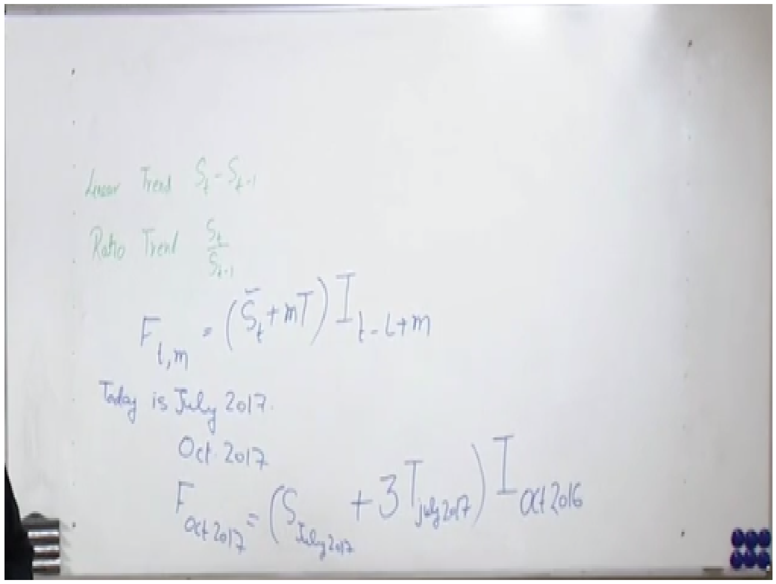

This is linear trend which is also known as additive trend. There can be another type of trend also, which can be ratio trend or multiplicative trend. In case of ratio or multiplicative trend the trend component is determined with this type of ratio. This is the formula. So, if I take the ratio trend here, if I take the multiplicative trend here. So, this way of calculating the trend will change. This St - St - 1, will become St upon St -1. And rest of the model will remain as it is.

So, we need to know that what type of model can be customised using this one of this general type of model. This is the most general type of forecasting model which we are discussing now and since this is been most general model you can see that we are using all 3 types of smothering constants. In last two, three sessions we have discussed about the smothering constants alpha, beta, gamma. This is one model where I am using all 3 types of smothering constants.

Alpha, to smoothen the fluctuations of the base value ‘S’. Then beta to smoothen the fluctuations of the trend value. And, then gamma to smoothen the fluctuations of the seasonal component seasonal index. So all three types of alpha, beta, and gamma are used here time and again. We have discussed that the values of alpha will lie between 0 to 1 value of beta will lie between 0 to 1 and values of gamma will also lie between 0 to 1.

But, the popular values of alpha beta gamma will be from 0.05 to 0.30. Now the lower values again we have discussed have more a smothering effect. You want more smothering effect used lower values of alpha, beta, gamma. But, sometime because of some happening in the environment whatever change, whatever disturbance has taken place in very recent past. I want to incorporate that disturbance completely in my model, completely in my forecasting model.

In that case I want to use higher values of alpha, beta, gamma whatever type of you all want to see that there is a complete shift in my base. I will use higher values of alpha. So that the most recent disturbance or most recent happenings at totally captured in the base or so on for the trend as well as for the seasonal index. Now let me start again with my the last formula that is Ft1 that is the forecast.

If I am in the month of July 2017 and I want to forecast for the August 2017. In that case t1. Ft represents July 2017 comma 1 represents August 2017. And in this case I will use the updated base value of July 2017 +updated trend value of July 2017 this is St+Tt. Then It-L+1 this we discussed in the last session also. This is the seasonal index of August 2016. So, these are the values of July 2017, this is the values of August 2016 multiplying this S + T by the seasonal index.

I get the forecast for August 2017. So, this is how you can interpret this generalised formula which is represented in terms of Ts and Ls. Now when I am using this formula I need the updated values of St and trend. So these are the updated values of St and t, but this value this updated value of seasonal index IT. This is not to be used in the current forecast, when I am doing forecasting for August 2017.

And I am calculating this IT which is for July 2017, so this is not to be used right now, this will be used in the next cycle for 2018. So I will used this formula where this Dt upon It- l represents the de-seasonalized demand of July 2017, and alpha is the smothering constant, whatever factor of the current demand I want to incorporate that will be represented by the alpha. Then this is the St-1+Tt-1 that is the previous base that is the base of June 2017 and this is the trend of June 2017.

Now once I have calculated the updated base value then it is a kind of iteration. I will use this updated base value here to calculate my updated trend value. You see you check first I need to do this calculation of St bar, and with the help of this St bar the second calculation will come for Tt that is St will be used here. This St bar St bar - this St-1which is for one period previous the beta multiplication of that.

This is the factor of my current trend, and this is the old trend, and this will I will get the updated value of the trend. So, this St and this Tt I am using here in the final forecasting multiplied by the old seasonal index of one period ahead. And, this seasonal index this updated seasonal index of July 2017 which is a smoothen with the help of this gamma a smoothening constant will be used for next cycle.

Now, when I am using this Ft 1. I can also use this equation for a generalised kind of forecast like this is for one period ahead but I can use same for M period ahead. I am in July 2017 right now. But, I want to forecast for two periods three periods four periods ahead using the current data. So that is M period ahead and in this case I will use the updated base value whichever is available to me + this trend Tt.

I will take the value of t as a constant now and this I will write simply as t, and I will multiply this by this M and same in case of seasonal index I will take the this 1 will be represent by M. So this will become t-L+M. So the point which I am trying to make here that if it is today it is July today is July 2017 and I want to forecast for October 2017. For August we have already seen. But now I want to apply the same formula for October 2017.

So, F October 2017 when today is July 2017 will be S of July 2017 this is the updated base value + now what is the value of M August 1, September 2, October is 3. So M is 3 in this case 3 and this T will be for the July 2017 x T of July 2017 close the bracket and the seasonal index of t-L+M though seasonal index of October 2016 that will be determine my forecast for October 2017 when I am today in July 2017 and similarly you can calculate for November.

You can calculate for December, you can calculate for September when you are in July 2017. Obviously there is one thing which can come to your mind that. When I am forecasting for higher values of M my forecasting errors will be high that is true. Because I am using slightly distant data for doing the forecast, So with higher values of M my forecasting errors are happen to be more.

And when I used only for one period ahead, I have more accurate forecast because I am doing forecasting with the most recent data in this case. But nevertheless many a times this forecast is also very useful, because it will help us in doing the appropriate planning for our supply chain. So this is also not to be discarded and this is also many a times very useful for doing the initial planning of the supply chain decisions.

So with this we discussed large number of forecasting models using the time series analysis particularly exponential smothering methods and if you remember we have discussed nine different types of models out of 9 different types of models we discussed in our class four different types of model. But the same type of models can be customized like with this general model you can use this model for any other type of forecasting model.

Because, of different ways of representing your trend, different ways of representing your seasonal index and accordingly you will have your forecasting. But depending upon your ability to identify right kind of characteristic in your demand data and the secondly the appropriate values of alpha, beta, gamma. So what we do normally with the different values of alpha, beta, gamma we prepare a table of MAD.

And whichever certain of alpha, beta, gamma gives as lowest value of MAD that set of data of alpha, beta, gamma will use for a particular data characteristic but in a real time environment when I am talking of more pro-activeness. So, many a times it is possible that during the course of our forecasting. If we are having our tracking signal going into a particular direction of either over estimating or low under estimating we need to change the values of alpha, beta, gamma intermediate also.

So, with this we have a very good discussion about our forecasting techniques the next important decision area in the supply chain is about the inventory. Once you have decided about the forecast. That this is the final forecast in your supply chain so next issue is about the inventory management. In the last class when we were discussing about the tracking signal. We discussed that if you are continuously doing the over forecasting.

If you are continuously doing the over forecasting in that case you will always be having some kind of inventory in your supply chain and that inventory is not desirable. Because, it will take away your profits. So, now the second important area where analytics will help as that is the inventory management. So now we will move to our discussions of inventory management where we will see that how inventory is to be managed.

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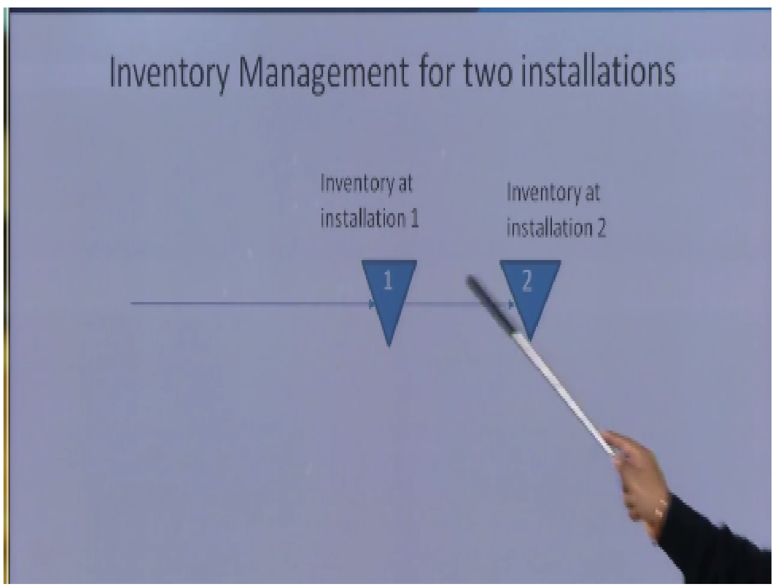

To start our discussion we have a very simple case where we have only a supply chain with two installations, though there will be many installations in a supply chain. But just to start our discussions of inventory we are considering a supply chain with two installations one and two. Over a period of time we will build more installation in your supply chain, but to start the discussion we have two installations.

Now you consider that installation 2 is the retailer and installation 1 is a wholesaler. So, installation 1 is a wholesaler and this is retailer, so wholesaler is responsible we all know wholesaler is responsible for supplying products to retailer. So, whatever inventory is managed at the retailers and that is coming from the wholesaler.

So now if you go to your operation management classes you know there is a method of inventory management which is very popular which is known as EOQ Economic Order Quantity model. Now we will start this process of inventory management with that EOQ model. In EOQ model you may recall that we keep inventory and inventory register to a particular label and then we start consuming inventory. So now we are seeing the same kind of inventory management for this two installations.

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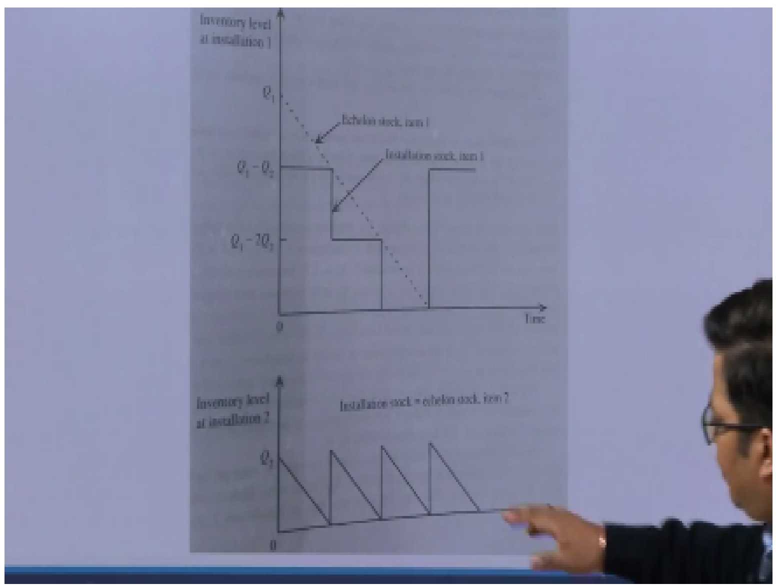

And, this can be represented with the help of this picture. Now, picture shows you that this is the inventory management at installation 2, where at installation 2 we are keeping inventory of Q items. At a time we ordered Q items at installation 2 and these Q items are coming from installation 1. So, now what we are doing at the installation 2, you are ordering Q items at a time then you are consuming these Q items, and over a period of time.

These Q items are consumed completely and then again you have already placed a order, so that by the time you reaches this zero level again year a stocks are replenished to the original Q 2 level and again you have the full stop at you start the consuming these by the time again you reach us to zero level. Your stocks again replenished to the original Q 2 level. And this is a very popularly known saw teeth pattern of inventory management.

So, at installation 2, you can clearly see the saw teeth pattern of inventory management where you are taking the items for consumption and you are receiving all Q2 in one lot and there is a slow rate of consumption which you are consuming. Since we are seeing that installation 2 is retailer, so you are selling products at retailers end, and maybe this period is one month period. So, you are consuming the Q 2 is stock in one month.

Let us assume this so this is a very popular saw teeth pattern. The EOQ model economic order quantity model is based on this saw teeth pattern. Now the inventory at installation 1, at installation 1 I am procuring Q 1 item from the manufacture. The wholesaler is procuring Q 1 items from the wholesaler. Now what happens when the owner of installation 1is procuring Q 1 items from the manufacturer.

So, if you see these two figures so whenever Q1 items are coming to installation 1 out of that Q 1, Q 2 items are coming to retailer. So this installation 1is receiving Q 1 items and out of that Q 2 items are given to installation 2. So the installation 1 is left with Q 1- Q 2 items and it will remain with Q 1- Q 2 items for sometime and whenever the next order is required by the installation 2.

In that case this further Q 2 items will be supplied to installation 2, so it will further reduced to Q 1-2Q 2 and then it will remain for sometime Q 1- 2Q 2.and then again when there will be a requirement of further Q 2 items at installation 2. So it means supply the remaining items to installation 2and this is stop will come to zero level at the installation 1. So what we have taken just for the sake of understanding that Q 1 is four times of Q 2.

Q 1 is four times to Q 2 because Q 2 Q1 is able to supplied four times to Q 2 out of it is originally stock and then it will remain like this for some period like 0. And, whenever the next order is expected at the installation 2, so this installation 1 will adjust it is supply requirement that whenever this next order is expected as installation 2. It will receive it is original Q1 order from the manufacturer on that very day. And, out of that Q1 items Q2 will immediately go to the installation 2. And it will remain with Q1- Q2.

And, the pattern will further be repeated. Now, when you see the inventory management at installation 1, you are seeing these thick lines, so these are the physical stocks which are available at installation 1. But, then you also see this dotted line you see this dotted line, and this dotted line is being plotted taking the corner points of these 2 stocks. And, the Q1 level the original Q1 level the item which the installation 1 is receiving from the manufacturer.

So, this line which is the line almost of this type. And, when I go for second round of receiving the order of Q1 quantity at installation 1. So, this will again come somewhere here. And, you will see that this pattern of dotted line can be represented at installation 1 also. So, what I am trying to say that you have same saw teeth pattern at installation 1 as well as at installation 2. So, we can apply this EOQ model very well at the installation 1 as well as installation 2.

Now, for applying the EOQ model there are certain assumptions, and let us discuss those assumptions, one assumption is that Q2 is always either equal to Q1 or less than Q1. Because, Q2 is coming from Q1, so Q2 cannot be more than Q1 any case. Depending upon the model it is quite possible that Q1 may be equal to Q2. But, Q2 can never be more than Q1, this is one assumption. The second assumption is that here are 2 types of cost which are involved in this model. One cost that is the cost of ordering.

So, at this level you are requiring Q2 items, and this level you are requiring Q1 item. Then the second assumption is that there is a cost of ordering, whenever, you are putting an order, so, there is a cost of ordering receiving the order loading, unloading etc. So, there is a cost that is all the cost at installation 2 by represented by subscript 2, and all the cost at installation 1 are represented by subscript 1. So, there will be cost associated at 1 and 2.

And, then there will be the holding cost, whatever items you are holding, you are blocking the money of your organisation in holding the items. You are putting some kind of insurance charges, you are putting some kind of rent on keeping those items. So, all these cost are associated with the holding cost. So, you are putting the holding cost also at each of these installations, whatever there in your supply chain.

So, the second cost is the holding cost, so holding cost and the order cost or in some literature it is mentioned as setup cost also. So, holding and setup cost at each of these installations is constant. So, there is no change in the holding and setup cost. So, we will take that is as our second assumption. Then third assumption is that whatever order we are placing at installation 2 or at installation 1.

We are receiving the complete supply, there is no short supply, if I am giving order of Q2 quantity, Q2 means let us say 100. So, I am receiving all 100 in 1. At Q1 let us say, I am giving the order of 400 units, so I am receiving all 400 in a single lot. So, that is another assumption, there is no short supply. Then there is a determined time when I am going to receive the supply. Today I am giving order and after four days I am receiving the supply.

So, the four day period is known as lead time. The time when I placing the order and the time when I receiving the supply this duration is known as lead time. So, lead time is also fixed. Otherwise this model will have some kind of problem. So, I take this assumption that whatever my supplier whatever my wholesaler says, that lead time is a constant. So, that is another assumption.

Then there is we have seen in the model that there is a constant slope of each of these teeth. The slope represent the consumption rate, the slope represents the consumption rate of my items. So this consumption rate is also constant. In this diagram, though in practical terms it is always impossible to say that you have a constant rate of consumption at the retailers end. There will be some fluctuations.

In our last classes of forecasting, we have discuss this in very detail, that you will never have these types of straight line of the consumption. There will be some kind of zigzag lines. But, for the purpose of modelling we assume that the rate of consumption is almost constant. So, that is also one assumption we are taking. Then one more assumption, we take for the simplification of our discussion.

That there is a direct integer multiplication of Q2 to get the Q1. For the sake of this model building I am considering that Q1 is a direct multiplication of Q2. So, in this case like Q1 is like 3 Q2. So, here in one Q1, I am giving order of 3Q2. You can say, you can argue why it is not 2.5 or why it is not 3.5. if it is 2.5 or 3.5 in that case I will not be able to match exactly with the cycle of my Q2.

So, there will be some kind of extra inventory holding at my installation 1, so to avoid that I take some integer multiplication of Q2 to get my Q1. So, these are the some of my assumptions we have taken more I will recommend that we can go through any class of inventory management where basic EOQ model is start, and all those assumptions are valid for our case. So, we are stopping this discussion at the moment. And in our next class we will see that how do we optimise the inventory management in case of supply chain. Thank you very much.